Summary of Presentation

Review of lake whitefish stocks in northern Lake Michigan, with special reference to stock structure and spawning site distribution in relation to Green Bay

to

The Lake Michigan Technical Committee

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Lake Michigan Lake Whitefish Task Group

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Prepared for
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Lake Michigan Committee
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by

The Lake Whitefish Task Group

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Abstract

Lake whitefish stocks have been recognized by fishers, managers, and researchers in all of the Great Lakes. However, the development of specific criteria for discriminating among these stocks has been restricted to Lake Huron, Lake Ontario, and to a lesser extent, northern Lake Michigan and Green Bay. Numerous and increasingly more powerful stock identification techniques and tools are now available. A review was conducted of publications, theses, reports, and data on lake whitefish stock structure of northern Lake Michigan, with special reference to Green Bay, to determine how well stock structure and spawning-site distribution are known. Although general harvest assessment and status report data are voluminous, there are not adequate quantitative data to recognize, discriminate, set harvest quotas, or manage lake whitefish in northern Lake Michigan and Green Bay on a discrete stock basis, given potential movement, stock dynamics, and the possible proliferation of new stocks. If more specific and adequate sampling is conducted and more recently developed and powerful stock discrimination techniques are applied, with validation, it should be possible to adequately discriminate, practically monitor, and more specifically manage the major lake whitefish stocks of northern Lake Michigan and Green Bay to optimize harvest and protect diversity. Such studies should involve collaborative work across the Great Lakes to better understand and describe "bay" and "lake" stock complexes (e.g., eastern Lake Ontario and Bay of Quinte).

A specific set of one-time research studies examining stock separation techniques involving genetics and calcified structure analyses is proposed to ground-truth discreteness and in conjunction with this to develop, if possible, practical, simple, and cost-effective techniques for routine application. At least four broad locations associated with Wisconsin (WMZ) and Michigan (MMZ) management zones should be sampled (lakeshore, Door Peninsula, North and Moonlight bays, WMZ—3; northern Green Bay, Big Bay de Noc, MMZ—01; central-west side of Green Bay, including rivers, MMZ—00; central-east side of Green Bay, bay side Door Peninsula, WMZ—2). Studies that could be considered would involve 1) a thorough survey of fishers and fisheries specialists to accumulate practical knowledge, 2) a spawning-time survey (see above) to locate the largest congregations of ripe and running females spawning and depositing eggs, 3) some limited tagging and recapturing to monitor dispersal and return, 4) collection and analyses of tissues and calcified structures—scales, otoliths, and fin rays, 5) spring sampling of concentrations of hatching or newly hatched fry, 6) analysis of fry genetics and otoliths, 7) some experimental trawling to locate suspected nursery grounds of young-of-the-year and yearlings, 8) some experimental gill-netting of summering grounds to assess degree of stock mixing of sub-adults and adults, and 9) sampling commercial harvest to assess degree of mixing and to compare and test routine and practical discrimination techniques. Analytical techniques would involve 1) molecular and nuclear genetic procedures, 2) trace element and stable isotope chemical analyses of otoliths, and 3) detailed analyses of scales and otoliths for unique shape, growth patterns, and thermal signatures.

Lake Michigan Lake Whitefish Task Group—Charge

1. Review available data on lake whitefish stock structure for the northern Green Bay fishery.

2. Describe stock structure and spawning site distribution of lake whitefish caught by fishers in northern Green Bay.

3. If data are not available to accomplish the above, design a study or studies to provide the necessary information.

Background

Lake whitefish stocks have been recognized by commercial fishers and fisheries managers and researchers in all of the Great Lakes. However, the development of specific criteria for discriminating among these stocks has been restricted to the Ontario waters of Lake Huron, Lake Ontario, and to a lesser extent, northern Lake Michigan and Green Bay.

Stock Identification Techniques—Materials and Methods

1. Spatial distribution
2. Population parameters and dynamics
3. Physiology
4. Behaviour
5. Morphology
6. Meristics
7. Calcified structures
8. Nuclear and molecular genetics
9. Cytogenetics
10. Immunogenetics
11. Colour pattern and anomalies
12. Parasites

Review

1. Reviewed all published sympatric lake whitefish stock studies, particularly those associated with the Great Lakes and northern Lake Michigan, and assembled more than 60 specific references associated with the review, including analytical techniques and their specific applications.

2. Reviewed all available theses (10), assessment and status reports, and documents assembled by Wisconsin (18) and Michigan (4) biologists.

3. Examined all available data and compiled an inventory of scale archives established by Wisconsin, Michigan, and the Inter-Tribal Fisheries and Assessment Program, encompassing a 32-year period and consisting of more than 108,000 samples.

4. Reviewed spawning ground survey of fishers in the Michigan waters of Lake Michigan.

5. Consult with those familiar with the area and experienced with the lake whitefish populations and fisheries.

General Conclusions of Review

1. Biologists of the state agencies have produced a large number of harvest assessment and status reports containing voluminous data on northern Lake Michigan lake whitefish. Published studies and theses usually considered two major stocks, one associated with the bay, Big Bay de Noc, and the other with the main lake, North and Moonlight bays.

2. We consider that at the present, there are not adequate quantitative data to recognize, discriminate, set harvest quotas, or manage lake whitefish in northern Lake Michigan and Green Bay on a discrete stock basis, given potential movement and

stock dynamics and possible stock differentiation.

3. If more specific sampling is conducted and recently developed stock discrimination techniques are applied, with validation, we suspect that the major lake whitefish stocks of northern Lake Michigan and Green Bay can be discriminated and be practicably monitored and sustainably managed, optimizing commercial harvest and protecting diversity.

4. Although studies would focus on northern Green Bay, collaborative work should be conducted across the Great Lakes to better understand and describe bay-lake stock complexes, in particular the well-documented example in eastern Lake Ontario and the Bay of Quinte.

5. Therefore, we specifically recommend a set of research studies examining different stock separation techniques involving genetics and calcified structure analysis.

General Sampling Locations in Northern Lake Michigan for Describing Putative Stocks

1. Lakeshore Door Peninsula and to the south, especially North and Moonlight bays (WMZ—3).

2. Northern Green Bay, especially Big Bay de Noc (MMZ—01).

3. Central-west side of Green Bay, especially the rivers (MMZ—00).

4. Central-east side of Green Bay, especially the bay side of the Door Peninsula (WMZ—2).

Possibly:
5. Southern Green Bay (WMZ—1)
6. Lakeshore northern Lake Michigan (MMZ—02).

Specific Recommendations

We recommend a set of specific research studies to collect detailed stock information to ground-truth discreteness and develop, if possible, more practical and cost-effective techniques.

1. That sampling be based on spawning stocks, confirmed by the presence of ripe and running females sampled throughout the spawning season.

2. That sampling surveys be conducted at several locations within each of the various management zones.

3. That one-time technically detailed research studies be conducted to confirm discreteness and validate stock origin.

4. That in conjunction with these one-time research studies, practical quantitative techniques and criteria be applied and developed to assign stock origin, incorporating error testing.

5. That these practical techniques be used in conjunction with commercial sampling to routinely determine age and stock origin (ideally from calcified structures) to monitor relative stock abundance and dynamics and to manage lake whitefish exploitation on a stock basis.

Research Sampling and Design

1. Conduct a systematic survey of fishers and species specialists familiar with lake whitefish in northern Lake Michigan and Green Bay to summarize the traditional knowledge that exists concerning specific spawning grounds of the major stocks for all waters, similar to the one conducted for Michigan waters by Organ et al. (1978).

2. Conduct spawning-ground surveys throughout the various

management zones (see list of locations), concentrating on locations indicated from the survey. Sampling should be systematic throughout the months of October and November, focusing on concentrations of ripe and running (by body weight) females and if possible confirm spawning and egg deposition.

3. **Tag and release some fish associated with these major assemblages for monitoring their dispersal and possible return. (Consider a tagging method that would substantially reward return of carcass.)**

4. **Sample ripe and running females and if possible males at the same time for detailed biological data, and remove tissue and structures for studying stock origin, particularly scales, otoliths, and fin rays.**

5. **Sample hatching or newly hatched fry the following spring at the largest spawning assemblages. This may require developing some new procedures for sampling fry before appreciable drift has occurred. At the same locations, sample sedentary species, such as sculpins, darters, and possibly zebra mussels.**

6. **Analyze fry, using genetic techniques; study otolith growth and chemistry and compare with other indicator species.**

7. **Conduct experimental bottom trawling in suspected nursery areas in the vicinity of the largest spawning and fry assemblages and sample young-of-the-year and yearlings and apply stock analysis techniques. Could also provide a useful long-term index of early stock abundance.**

8. **Experimentally gill-net summering grounds to sample subadult and adult fish to determine the degree of stock mixing. This could help explain movements, dynamics, and stock discrimination inconsistencies.**

9. **Sample commercial harvest to apply practical procedures developed and validated in the above research studies to assess degree of mixing and discreteness and develop and test routine sampling and monitoring procedures.**

Analytical Techniques

Emphasize genetics and calcified structure growth and chemical analyses, but also consider, where possible, spatial distribution and population dynamics.

1. **Use refined, modern analytical techniques, examining genetic variability. Employ molecular genetic markers using nuclear and mitochondrial DNA. Employ variable number of tandem repeat minisatellite and microsatellite loci and polymorphic interspersed nuclear elements such as SINEs and transposon sequences.**

2. **Conduct detailed analyses of calcified structure growth involving scale and otolith camera-digitized shape and growth pattern characteristics, including subannual features. Consider scale check type, extent, and circuli spacing, use the unique growth and thermal "signatures" permanently recorded in early daily incremental growth of the otoliths, and apply CSAGES to examine growth sequencing in calcified structures of older fish.**

3. **Use trace element and stable isotope fingerprints in otoliths to examine natural markers; these have been shown to identify stocks of fish when microsatellite DNA was unable to. Computerized micromilling or laser ablation ICPMS permit detailed topographical analysis with very low limits of detection and provide powerful discrimination that can be linked to potential origin but can also track subsequent habitat associations.**

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Table 1. Inventory of lake whitefish scale samples for Lake Michigan archived by the states of Wisconsin, Michigan, and Inter-tribal Fisheries and Assessment Program (ITFAP) for a 32-year period from 1968 to 1999 by Wisconsin Lake Whitefish Management Zones W1, W2—bay and W3, W4, W5—lake and by Michigan Lake Whitefish Management Zones M00, M01—bay and M03 to M08—lake (see Fig. 4). For comparative purposes, ITFAP samples, inventoried by grid, were combined into Wisconsin and Michigan management zones. More specifics concerning the archive are available in Appendix C-1 for Wisconsin samples by year, area (bay and lake), and month; Appendix C-2 for Michigan samples by year, management zone, and month; Appendix C-3 for ITFAP samples by year, grid, and management zone.

Year	Origin	W1, W2	W3, W4, W5	M00	M01	M02	M03	M04	M05	M06	M07	M08	Total
1968	WI		88										88
	Comb.		**88**										**88**
1969	WI		68										68
	Comb.		**68**										**68**
1970	WI	25											25
	Comb.	**25**											**25**
1971													
1972													
1973	WI	600	235										835
	Comb.	**600**	**235**										**835**
1974	WI	523	400										923
	Comb.	**523**	**400**										**923**
1975	WI	12	100										112
	Comb.	**12**	**100**										**112**
1976	WI		75										75
	Comb.		**75**										**75**
1977	WI	330	525										855
	Comb.	**330**	**525**										**855**
1978	WI	50	1,020										1,070
	Comb.	**50**	**1,020**										**1,070**
1979	WI	50	275										325
	IT								42				42
	Comb.	**50**	**275**						**42**				**367**
1980	WI	130	40										170
	IT				26		1						27
	Comb.	**130**	**40**		**26**		**1**						**197**
1981	WI	164	340										504
	IT						131	248	788				1,167
	Comb.	**164**	**340**				**131**	**248**	**788**				**1,671**
1982	WI	365	194										559
	IT					200	397	400	989				1,986

	Comb.	**365**	**194**			**200**	**397**	**400**	**989**				**2,545**
1983	WI	140	123										263
	IT					197	440	349	1,470		325		2,781
	Comb.	**140**	**123**			**197**	**440**	**349**	**1,470**		**325**		**3,044**

Table 1 (cont'd)

Year	Origin	W1, W2	W3, W4, W5	M00	M01	M02	M03	M04	M05	M06	M07	M08	Total
1984	WI	565	1,025										1,590
	IT								1,125				1,125
	Comb.	**565**	**1,025**						**1,125**				**2,715**
1985	WI	459	1,040										1,499
	IT							39	137				176
	MI			1,684	2,154					307		324	4,469
	Comb.	**459**	**1,040**	**1,684**	**2,154**			**39**	**137**	**307**		**324**	**6,144**
1986	WI	930	908										1,838
	IT					215	346	270	1,315				2,146
	MI			402	2,138					248		612	3,400
	Comb.	**930**	**908**	**402**	**2,138**	**215**	**346**	**270**	**1,315**	**248**		**612**	**7,384**
1987	WI	365	1,669										2,034
	IT					320	321	136					777
	MI			514	1,426					328		557	2,825
	Comb.	**365**	**1,669**	**514**	**1,426**	**320**	**321**	**136**		**328**		**557**	**5,636**
1988	WI	576	1,060										1,636
	IT					264	272	336					872
	MI			764	1,810					458		1,131	4,163
	Comb.	**576**	**1,060**	**764**	**1,810**	**264**	**272**	**336**		**458**		**1,131**	**6,671**
1989	WI	406	1,268										1,674
	IT					221	492	330					1,043
	MI			730	1,904					505		594	3,733
	Comb.	**406**	**1,268**	**730**	**1,904**	**221**	**492**	**330**		**505**		**594**	**6,450**
1990	WI	586	1,195										1,781
	IT					299	370	350					1,019
	MI			746	1,065					738		737	3,286
	Comb.	**586**	**1,195**	**746**	**1,065**	**299**	**370**	**350**		**738**		**737**	**6,086**
1991	WI	270	914										1,184
	IT					308	728	375	51				1,462
	MI			433	1,109					474		726	2,742
	Comb.	**270**	**914**	**433**	**1,109**	**308**	**728**	**375**	**51**	**474**		**726**	**5,388**
1992	WI	107	914										1,021
	IT				216	382	680	285					1,563
	MI			251	927					434		642	2,254
	Comb.	**107**	**914**	**251**	**1,143**	**382**	**680**	**285**		**434**		**642**	**4,838**
1993	WI	100	993										1,093
	IT					420	934	275					1,629
	MI			702	1,149					490		645	2,986
	Comb.	**100**	**993**	**702**	**1,149**	**420**	**934**	**275**		**490**		**645**	**5,708**

Table 1 (cont'd)

Year	Origin	W1, W2	W3, W4, W5	M00	M01	M02	M03	M04	M05	M06	M07	M08	Total
1994	WI	100	1,135										1,235
	IT					649	1,057	505					2,211
	MI			799	1,512					254		640	3,205
	Comb.	**100**	**1,135**	**799**	**1,512**	**649**	**1,057**	**505**		**254**		**640**	**6,651**
1995	WI	165	1,068										1,233
	IT				352	207	687	276					1,522
	MI			653	1,505					407		741	3,306
	Comb.	**165**	**1,068**	**653**	**1,857**	**207**	**687**	**276**		**407**		**741**	**6,061**
1996	WI	73	932										1,005
	IT				95	502	1,365	541					2,503
	MI			674	1,402					408		483	2,967
	Comb.	**73**	**932**	**674**	**1,497**	**502**	**1,365**	**541**		**408**		**483**	**6,475**
1997	WI		1,240										1,240
	IT					834	1,877	1,056	117				3,884
	MI			790	1,396					488		700	3,374
	Comb.		**1,240**	**790**	**1,396**	**834**	**1,877**	**1,056**	**117**	**488**		**700**	**8,498**
1998	WI	70	932										1,002
	IT					556	1,753	886					3,195
	MI			456	956					155		518	2,085
	Comb.	**70**	**932**	**456**	**956**	**556**	**1,753**	**886**		**155**		**518**	**6,282**
1999	WI		480										480
	IT					992	1,309	549					2,850
	MI			525	1,201					199		600	2,525
	Comb		**480**	**525**	**1,201**	**992**	**1,309**	**549**		**199**		**600**	**5,855**
Total	WI	7,161	20,256										27,417
	IT				689	6,566	13,160	7,206	6,034		325		33,980
	MI			10,123	21,654					5,893		9,650	47,320
	Comb.	**7,161**	**20,256**	**10,123**	**22,343**	**6,566**	**13,160**	**7,206**	**6,034**	**5,893**	**325**	**9,650**	**108,717**

From Draft Report

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